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## The Nature of Atmospherics


BY F. J. W. WHIPPLE, M.A.


THE nature of atmospherics, the electrical disturbances which interfere at times with the reception of "wireless" messages, is a subject of interest to meteorologists as well as to the electricians whose aim it is to eliminate the effects of the disturbances in the practice of telegraphy. Some atmospherics are no doubt due to distant thunderstorms, but whether they can originate in the atmosphere without the occurrence of lightning, and whether they have sometimes an extra-terrestrial source are open questions. Hitherto, the principal difficulty in coming to close grips with the subject has lain in our ignorance of the nature of the electric waves. In a paper which has just been published*, Messrs. Watt and Appleton record their success in overcoming this difficulty, success which is in part to be attributed to the use of a new type of cathode ray oscillograph made by the Western Electric Company.

To analyse electric waves of extremely short duration, such oscillographs as are used for ascertaining the wave-form in the alternating currents made by dynamos and which depend on the movement of a galvanometer mirror are obviously unsuitable. In the cathode ray oscillograph there is a jet of electrons which plays on a fluorescent surface. This jet can be deflected by the application of transverse electric forces, and the variation of these forces is shewn by the movements of a bright spot on the fluorescent surface. The apparatus is connected up in such a

* *Proc. Roy. Soc.* A. April, 1923, pp. 84-102.


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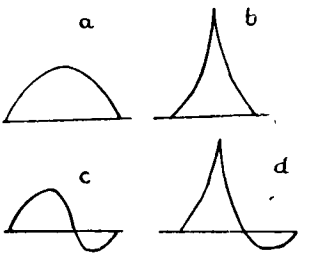
way that regular oscillations of known periods move the spot right and left whilst the electric force to be investigated moves the spot up and down. Owing to the persistence of vision the path of the spot is seen as a bright curve.

In the researches under review, which were conducted by Watt and Appleton at the Radio Research Board Station at Aldershot, the atmospherics were caught by an aerial 500 metres long and 15 metres above ground. The characteristic wave-forms which were observed are shewn in the accompanying figure.




It will be seen that there are various types; the waves are either aperiodic, the disturbance rising to a maximum and then falling rather more slowly, or quasi-periodic, the disturbance rising to a maximum, falling to zero and changing sign. In either case the disturbance can be positive or negative, driving positive electricity downwards from aerial to earth or *vice versa*, and again the wave form may be peaked or rounded. Of the aperiodic waves the negative types are by far the more frequent; the numbers of quasi-periodic and aperiodic atmospherics are about equal. The rounded waves in either of these forms are nearly $2\frac{1}{2}$ times as frequent as the peaked. The crest of the wave corresponds most frequently with a vertical gradient of about 4 volts per 100 metres; the highest voltage recorded was 80 volts per 100 metres. Peaked waves give higher voltages than rounded waves, the ratio being a little higher than 2 to 1.

The duration of the atmospherics is found to be of the order of two-thousandths of a second. The lengths of the waves in space must therefore be comparable with 600 kilometres. The fluctuations in voltage involved in atmospherics are quite modest when compared with the persistent gradient of electric force in the atmosphere, though enormous in comparison with the fluctuations produced by radiotelegraphic signals. The normal vertical gradient of electric potential is of the order 20,000 volts per 100 metres, so that in one sense the atmospheric represents a mere ripple. On the other hand, the gradients produced by transatlantic radio signals are of the order of ·0005 volt per 100 metres, and very strong signals run to ·1 volt per 100 metres. In comparison with these signals the atmospheric is a tidal wave.

It will be seen that a wide field of investigation has been opened up. Considering that the new and improved cathode

ray oscillograph of the Western Electric Company was exhibited in this country for the first time only in November last, it is remarkable that such far-reaching results should have been obtained with it already.

The improvement in question by which the cathode rays are made to give a small bright spot on the fluorescent screen is very pretty; but that is another story.†

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## Winter Thunderstorms.

By Captain C. K. M. Douglas, M.A.

RECENT discussion of the causes of winter thunderstorms has centered on the relative importance of the vertical and horizontal temperature gradients. The two factors may clearly operate together, and it will probably prove difficult to estimate their precise influence without some knowledge of the lapse-rate of temperature. Since actual observations of upper air temperature are not as a rule available, it would be valuable if more detailed information of cloud forms could be obtained. The winter thunderstorms are often accompanied by large cumulo-nimbus clouds with "anvil" tops similar to those of summer, which are visible for a considerable distance, and are seldom limited to one locality. I have fairly frequently flown near or through the tops of "anvils" in winter, occasionally on days when thunder occurred in the neighbourhood, and found that the tops usually reached the 4-kilometre level and often exceeded it, though of course the average height was less than in summer. The lapse-rate of temperature up to the 4-kilometre level on these occasions was always fully up to the saturated adiabatic rate, which in winter implies a lapse-rate considerably above normal. Though a horizontal temperature difference may well cause violent convection in the lower air, and consequent thunder, it seems hardly possible that the strong upward current could reach 4 kilometres unless the lapse-rate were sufficiently high. The vertical currents which produce large cumulo-nimbus clouds are of course quite different from the mass movements up surfaces of discontinuity.

At Eskdalemuir Observatory in the winter 1921-22, a careful watch was kept for the large cumulo-nimbus form, and it was seen on the great majority of the days when thunder was reported at Scottish stations within 100 miles. Observations of upper air temperature at Leuchars or Baldonnell were available on

† *Physical Society, Proc.*, 35 (2) p. 122, *Feb.* 1923.

only five of the days when thunder occurred at any Scottish station reporting to the Meteorological Office, and it is noteworthy that on every occasion the lapse-rate was high to the limit of the ascent. On the other hand there were several days when surface temperature over Scotland was uniform and rather low and thunder occurred locally, and on three occasions (Dec. 20th, 1921, Feb. 27th and 28th, 1922) at a considerable number of places. The only other equally widespread storm during the winter in Scotland was of true line-squall type, on the evening of Feb. 26th. On the whole, the facts support the conclusion of Mr. E. V. Newnham* that for the majority of the storms the primary factor is a high lapse-rate of temperature, caused by a cold current passing over a warm sea. The fact that individual storms may develop some of the characteristics of line-squalls is quite consistent with this conclusion.

Captain Cave† has shown that during the first three months of the four years which he investigated, storms occurred on as many as 41 per cent. of the days. It is obviously unlikely that the lapse-rate of temperature was high up to 4 kilometres on all these days, but it may easily have been high on most of them, for the upper air temperature fluctuates so rapidly in stormy weather that it might be low at the time of a thunderstorm, but not for a 24-hour period. Strong evidence in favour of a predominance of high lapse-rates near the surface off our west coasts in winter is provided by the observations of air and sea temperature plotted in the *Daily Synoptic Charts of the North Atlantic* published by the Deutsche Seewarte and the Danish Meteorological Institute. Taking for example the first three months of 1910, we find that out of 864 observations between the parallels of 45° N and 60° N and the meridians of 10° W and 40° W, the air temperature at deck level (read to nearest degree C.) was lower than the sea temperature (read to nearest tenth) on 658 occasions, and that on 533 occasions, or 62 per cent. of the total, the air temperature was as much as a degree lower. The predominance of cases with the air colder than the sea was particularly well marked during stormy periods in January and February when thunderstorms were frequent in the west. For example during the period February 13th to 22nd the proportion rose to 90 per cent., and on the average of all observations in that period the air was as much as 4° C. (7° F.) colder than the sea.

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* *Professional Notes No.* 29, M.O. 245 i.

† *Q. J. R. Met. Soc.*, xlix, No. 205, p. 43.

# OFFICIAL NOTICE

## Summer Time

"SUMMER TIME" will begin this year on April 22nd and will continue until September 16th. Observers are reminded that it is important to state explicitly the standard of time on all communications with regard to natural phenomena observed during the summer months.

## Discussions at the Meteorological Office

March 19th, 1923. *Classification détailée des nuages à l'Observatoire de Montsouris.* By Louis Besson (Ann. des Services Techniques d'Hygiène de la Ville de Paris, 1921).

*Opener*—Captain C. J. P. Cave.

The types of cloud merge so gradually into each other that there is no limit to the number of forms that can be distinguished by the ingenious. The impression left by reading through the list adopted by the Montsouris Observatory is that few observers can hope to master it so as to use it with confidence. There may be advantages, however, in having such a system. If it is used systematically for a considerable period, information as to the frequency with which cirrus, for example, assumes different forms will be gained and deductions as to the importance of certain physical processes may follow. M. Besson has deliberately adopted the rule of not providing photographs to illustrate the classification; the observer has to judge by the written specification. As a guiding principle, words ending in "us" are used to subdivide the broad classes of the international system, whilst words with the termination "um" indicate associated features. As an example we may cite "alto-cumulus globosus; velum." The first term is defined thus: "*Alto-cumulus globosus,* ou ronds, composés de balles sphéroïdales, à contour plus tranché en haut, un peu déchiré en bas. C'est la forme typique et en quelque sorte classique;" for "velum" we have "Voile discontinu *absolument invisible* inférieur à une nappe d'a-cu. serrés, dont il éclipse momentanément les interstices. Lorsqu'on suit à la herse néphoscopique le déplacement d'un bord blanc d'a.-cu., on assiste parfois à la disparition subite de cet objet, qui reparaît généralement une demi-minute ou une minute après. Nous avons été plus d'une fois témoin de ce phénomène, sans avoir jamais pu apercevoir le voile nuageux qui le produit en s'interposant entre l'œil et la nappe moutonnée."

It may be remembered that Mr. R. F. Granger referred to the frequent occurrence of a veil of this type in his paper on *The physical structure of cloud-form in the lower atmosphere**. The convenience of a technical name for such an interesting phenomenon must be admitted. The view taken by Captain Cave and the other speakers who took part in the discussion was, however, that they would have little use for the elaborate nomenclature adopted by M. Besson. It was felt that the first duty of an observatory associated with a weather service was to determine the heights of the clouds, their thickness and their density. For the close study of the distribution of cloud over the country, reports showing the bearing of the clouds from which maps for different heights could be constructed would be of great interest. For such purposes determinations of cloud height at numerous places are desirable.

The opinion was also expressed that such assumptions as are involved in the use of the name alto-cumulus are to be deprecated. If cirro-cumulus, alto-cumulus and strato-cumulus are essentially of the same character and differ only in height it is misleading to use three names. The Commission appointed by the International Meteorological Committee to revise the definitions of clouds will no doubt take such points into consideration. Such work as M. Besson's should prove of great service to the Commission.

## Royal Meteorological Society

THE meeting on March 21st at 49, Cromwell Road, South Kensington, was devoted to the customary March lecture, Dr. C. Chree, President, in the chair.

*G. M. B. Dobson, M.A.—Characteristics of the atmosphere up to 200 kilometres as obtained from observations of meteors.*

The principle theme of Mr. Dobson's lecture was the advance made in our knowledge of the constitution of the upper atmosphere by the discussion of the circumstances in which the kinetic energy of meteors is converted into light. A short account of the method was given in the last issue of *The Meteorological Magazine.*

Two new lines of attack were mentioned in the lecture. One was the separation of the observations of meteors into summer and winter groups. One of the most curious features of these observations is that few meteors vanish in the region between 50 and 60 kilometres above the earth's surface, though a con-

* *Q. J. R. Met. Soc.*, Vol. xlvii., 1921, p. 271.

siderable proportion of the total get lower than the 50-kilometre level. This characteristic is now found to be especially well marked in the summer, from which fact it may be deduced that the contrast in temperature between the stratosphere and the warmer atmosphere above it (which Mr. Richardson wishes to call the empyrean) is greater in summer than in winter.

The other new development is the application of photography to the determination of meteor tracks. By the exposure of photographic plates for long periods at two stations a few miles apart an occasional meteor may be recorded on both. Moreover the use of a rapidly revolving shutter in one of the cameras provides time marks on the corresponding trail and the speed of the meteor can therefore be obtained with a high order of accuracy. Since eye observations of meteors leave much to be desired in this respect the probable error of the estimate of the time of passage of a meteor, about a second, being of the order of 50 per cent., the application of photography marks a great advance. Mr. Dobson showed an excellent pair of photographs to illustrate his success.

It should be added that the lecture was notable for the skill with which such a technical subject was explained.

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# Correspondence

To the Editors, *The Meteorological Magazine.*

## Black Rain on the Comeragh Mountains

ON yesterday morning, March 23rd, I measured 7·7 mm. of seemingly sooty water from our rain-gauge. There is no chimney near it and the direction of the nearest chimney, 100 yards, is south-south-west. The wind was, and had been, north-easterly, hence it was blowing from the gauge to the chimney, which is only a domestic one ; there are no manufactories about. Thursday and Friday were unusually dark and gloomy, the atmosphere at times seemed like that of Manchester or Leeds. I venture to suggest that smoke laden rain-clouds from the Lancashire neighbourhood were precipitated here on Thursday. We had had nine rainless days ; rain began about 8 a.m. on Thursday and continued as mist or rain all day. The rain measuring glass always contains clear pellucid water. I never remember previously seeing it sooty, and regret that at the moment it did not occur to me to preserve it for examination. Since the 14th of March the wind has been mostly from easterly points.

J. ERNEST GRUBB.

*Seskin, Carrick-on-Suir, March 24th,* 1923.

## Meteorology and Folklore: More about the Wind

To primitive man one of the most surprising facts in Nature was that air, one of the gentlest and most impalpable of natural objects, could also be one of the strongest and most destructive. So we have the tale of the Maruts, or "crushers," who rage over the tree-tops in their fury, with the rain for their garments, but, when their work is done, assume the form of new-born babes. The weird shrieks of the wind have given rise to many a wild tale. The peasants of mediæval England heard the wailing of unbaptized children in the wind, and the Tyrolese tell of the "poor souls" in the autumn storms. Throughout the Teutonic world there is the tale of the "Wild Hunt" of spirits rushing howling through the air on stormy nights. Since the XVIIth century, at least, it has been associated with Christmas in Germany, and in Iceland it is called the Yule host. Often the old Teutonic wind-god Woden is the leader of the Wild Hunt, and in Norway it was once believed that the old Norse gods made war on Christians on Christmas Eve, coming down from the mountains with wild shrieks and great blasts of wind, and carrying off any unsuspecting mortal.

An old writer gives an interesting account of a magic stone in the Fladda Chuan Island, which was regarded as a wind-charm:—

> "There is a chapel in the isle dedicated to St. Columba. It has an altar in the east end and therein a blue stone of a round form on it, which is always moist. It is an ordinary custom, when any of the fishermen are detained in the isle by contrary winds, to wash the blue stone with water all round expecting thereby to procure a favourable wind . . . . And so great is the regard they have for this stone, that they swear decisive oaths upon it."

The Scottish winter-hag was called Cailleach, or "old-wife." She lived on Ben Nevis, where she kept imprisoned a beautiful maiden who was loved by her son. When he eloped with the prisoner, his mother raised storms to keep them apart and prevent the grass from growing. These storms are named in the Gaelic Calendar as the "Pecker," the "Whistle," the "Sweeper," the "Complaint," etc. In the end the son pursued his mother on horseback and she transformed herself into a moist grey stone. (Mackenzie, *Ancient Man in Britain.*)

The classic hierarchy of wind-gods is very familiar. In the Odyssey, Aeolus, their King, dwells upon an island, and when he is visited by Ulysses gives the hero the contrary winds tied up in a bag. The tale is well known how the greedy sailors unfastened the bag to their own undoing. Virgil pictures the winds imprisoned in a cave, from which on one occasion they were released by Juno's malice to vex the pious Aeneas.

CICELY M. BOTLEY.

10, *Wellington Road, Hastings, February 26th*, 1923.

## Anti-Solar Rays

THIS phenomenon,* which has been called by Abercromby and several other meteorologists " anti-crepuscular rays," is one of several (including, for example, the will-o'-the-wisp) which figured much more extensively in the older literature of meteorology than they do in the books of to-day. There is a voluminous literature on the subject, dating back to the middle of the 18th century. A partial abstract of this literature will be found in the Article *Les Deux Soleils*, by Henri de Parville, published in *La Nature*, Paris, 1901, deuxième semestre, pp. 419-420. There are cases on record in which rays of this character have been seen extending entirely across the sky.

C. F. TALMAN.

*Weather Bureau, Washington, D.C. March 9th*, 1923.

# NOTES AND QUERIES

## Upper Air Reports from Lindenberg

THE monthly report of upper air data published by the Prussian Aeronautical Observatory at Lindenberg, to which reference was made in *The Meteorological Magazine*, December, 1922, is now supplemented by a graphical representation of conditions in the first four kilometres above the surface. Copies for November and December, 1922, have been received in the Meteorological Office.

The variation throughout the month of the height above Lindenberg of surfaces of equal potential temperature is represented on a framework in which abscissæ represent time and ordinates height. The isopleths of potential temperature refer to a standard pressure of 750 mm., and are drawn for intervals of 2° C. Surfaces described as " sliding surfaces " are similarly represented on the same framework. Arrows differentiate those inclined surfaces at which air is moving upwards from those where it is sinking.

The diagrams show the passage past Lindenberg of " warm fronts," " cold fronts " and " occlusions," and a prominent feature is the pronounced dip in the lines of potential temperature during the passage of a " warm sector." They also show that a " sliding surface " of one form or other was practically always to be found in the first four kilometres above Lindenberg. For the purpose of interpreting fully the distribution of potential temperature a knowledge of the distribution of water in the air is required : it would therefore be an improvement if cloud layers and vapour pressure could be indicated on the charts.

* See *The Met. Mag.*, Feb. 1923, pp. 3-5.

The charts are printed rather crudely on indifferent paper, and, as the diagrams run close up to the left-hand edge of the paper, they are not convenient for filing and binding. But in spite of these minor defects the series represents a welcome addition to the synoptic representation of meteorological conditions.

## A Detonating Meteor (?)

MYSTERIOUS sounds were heard in the neighbourhood of Seskin, Carrick-on-Suir, on February 1st, 1923, between 16 h. and 17 h., and again at 22 h. Mr. J. Ernest Grubb has collected several reports of this "great noise in the mountains."

The noise is likened to "thunder" and to "lakes overflowing," and to "motor cars or a threshing engine passing along or like a winnowing machine." Another observer agreed that the noise was "like machinery," but says "It was not like thunder." In one case the noise was described as a "great roaring . . . like a storm gathering in the mountains," while another observer, who said the noise was like "the explosion of bombs or thunder," "thought that a battle was going on in Co. Waterford."

The mountains referred to in the different reports are the Comeraghs and Peaks, about eight miles south-west of Seskin, 2,600 feet high.

Mr. Grubb says: "It was *quite* calm here when the noises were heard, 4-5 p.m. There had been a strong breeze or high south-west wind in the forenoon and we had the same south-west wind later up to 9 p.m. or so."

It was thought that military operations in the neighbourhood might have caused these noises, but three armed Republicans, questioned by Mr. Grubb, stated that no battle was taking place on that date, and that they themselves had heard the noises from the mountains. Mr. Grubb adds that the people in Seskin are only too familiar with the sound of the various weapons in use, and that "none of them, or no combination of them, could have created these sounds, besides, they came right out of the mountains where there are neither roads or tracks or men."

Mr. Denning, to whom Mr. Grubb's account has been submitted, accepts the suggestion that the detonation of meteors may have produced the noises,* although there is as yet no more direct evidence.

* Cf. this magazine for April 1922, p. 269.

## Agriculture and Climatology in the Tropics

THE importance of the study of climatology in connection with tropical agriculture is emphasized by two recent publications.

The first of these, *The Forest Officers' Handbook of the Gold Coast,** has been prepared by Major T. F. Chipp, who has lately returned to this country as Assistant Director of Kew Gardens. It contains in Chapter V. a valuable discussion of the climate of the Gold Coast and its relation to forest distribution. The country is divided into four regions, according to the vegetation, namely, Evergreen Forest, Deciduous Forest, Inland Savannah and Coast Savannah, and it is found that, while there is good evidence of a relationship between the annual rainfall and the distribution of the type of vegetation, the number of rain days is also of importance. A heavy annual rainfall falling on comparatively few days is of equal value with a lighter rainfall spread over a larger number of days. This relationship is shown on a diagram in which rainfall is plotted against rain days. A brief calculation shows that the product, *rainfall in inches* × *rain days* is :—Evergreen Forest, greater than 6,500 ; Deciduous Forest, 6,500 to 4,500 ; Inland Savannah, 4,500 to 2,250 ; Coast Savannah, less than 2,250. But owing, presumably, to changes in the rainfall since the forests were established, the limits of the vegetation and rainfall districts do not quite coincide. This is a point of great importance in questions of re-afforestation where the forest has recently been destroyed.

The most marked influence of the forests is in maintaining the relative humidity, and their destruction has the effect of lowering the average humidity, especially during the dry season. As the successful growth of the cocoa, kola and oil-palm crops requires a constantly high humidity, it appears that the almost complete clearing of the country would involve the disappearance of these crops. The duty of the Government is, therefore, to maintain the forested area at such a level as will give to the crops sufficient protection against desiccation, while providing as large an area as possible for agriculture.

The purpose of the second, a paper on *Cane Sugar and Irrigation*,† is to show that the sugar cane crop in Natal would be benefited if the rainfall were supplemented by irrigation, and it includes a valuable discussion of the climatic requirements of this plant. In regions where irrigation is not practised, the rainfall exceeds 42 in. a year, of which the bigger proportion,

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* *The Forest Officers' Handbook of the Gold Coast, Ashanti and the Northern Territories.* By T. F. CHIPP. 9¾ × 6¼. Pp. 150. *Illus.* Published for the Government of the Gold Coast by the Crown Agents for the Colonies. 1922.

† *Cane Sugar and Irrigation.* South African Irrigation Department Magazine. Vol. 1. 1922. Pp. 209-216.

generally more than two-thirds, falls in the warmer half of the year. During this period it is fairly evenly divided and averages more than 4.75 in. per month in all areas. The harvesting and milling must be done in a relatively dry period, otherwise the sugar deteriorates. As regards temperature, the chief limiting factor is frost, and except under special conditions, the crop is limited to the belt between 32° N and 32° S. Within these limits sugar cane is grown at all latitudes, but it is desirable that there should be some seasonal variation in temperature. For this reason the best results are obtained in places such as Cuba and the Hawaian Islands, which are as far as 20-23° from the Equator.

The paper is accompanied by a valuable table showing the monthly rainfall and the times of planting and harvest in sixteen sugar-growing countries.

## The Frost Service of Southern California

A GOOD deal of scepticism has been exhibited in this country as to the practicability of warding off frost by local heating. The question is regarded seriously in the United States and we learn with interest* that as a result of the experience of last year, when half the crop of lemons and oranges in California was cut off by a frost in January, hundreds of thousands of new orchard heaters have been installed in the orange and lemon groves and that " flying squadrons " are being organised to aid the " orchardists " to fire the heaters. There are eight Weather Bureau employees engaged in the work of forecasting frost in Southern California. At 137 of the 204 special temperature stations thermographs are in operation. We do not know how far fruit growers in this country are adopting similar measures to ward off the dreaded spring frosts.

## The Meteorological Station on New Year Island

WE learn from Mr. R. C. Mossman that the meteorological and magnetic station which has existed for nineteen years on New Year Island is to be closed. The station, which is near Cape Horn, in 54°39′S was maintained in connection with the light-house, and we gather that since the opening of the Panama Canal the traffic round Cape Horn has fallen off so much that the cost of maintaining the light is no longer thought to be justified. The loss of one of the most southerly stations in the world will be regretted by meteorologists. It is deplorable at a time when navigators are learning to appreciate the advantages of obtaining wireless messages from the shore with details

*See the *Bulletin of the American Meteorological Society*, February, 1923.

of the meteorological situation. Data for New Year Island for the years 1902 to 1905 were published by Mr. Mossman in the *Quarterly Journal of the Royal Meteorological Society*, 1920, p. 90 and summaries for 1914 and 1915 are included in the *Réseau Mondial*.

## Smoke Abatement Legislation

ON Friday, March 23rd, a deputation waited on the Earl of Onslow, Parliamentary Secretary to the Ministry of Health, to discuss the proposed new legislation to prevent excessive pollution of the air by smoke from factory chimneys. The principal spokesman was Professor Bone of the Imperial College of Science. He stated that industry as a whole realised fully the importance of obtaining abatement of smoke nuisance. It should be realised, however, by those who were responsible for the introduction of legislation that they would, unless the very greatest care was taken, imperil the industry of this country and absolutely ruin the commercial efficiency of trade. This could not be the wish of His Majesty's Government, and therefore he urged that legislation should be dropped. He had no wish that attempts to modify and abate the nuisance should also drop, but there were methods by which this could be tackled which would help to the desired result without endangering either the commercial stability of industry or impairing the efficiency of manufacture, and therefore the federation strongly suggested the desirability of going into a much more thorough survey of the problem, not by a new enquiry, but by research and practical examination of the whole of the factors affecting fuel utilization in specific trades.

The Earl of Onslow, in reply, stated that the Government did not desire to produce legislation which imperilled industry, and he would welcome suggestions which might be incorporated in the new Bill for the purpose of giving adequate protection to industry.

## Widespread Atmospheric Pollution

ON Friday, March 23rd, the most popular steeplechase of the year, the Grand National, was run at Aintree, near Liverpool, in dense haze, which prevented the spectators in the stands from seeing half the race. The dirt-laden air extended over a large area in the north of England and over the Irish Sea, hiding the horizon at the North Wales watering places and, as the letter from Mr. J. E. Grubb, on p. 55 shows, the rain brought down a sooty deposit at Seskin on the far side of Waterford.

## Soaring Flight

IN *The Meteorological Magazine* for March, 1921, some account was given of Dr. Hankin's observations of the soaring flight of birds, dragon-flies and flying-fish.

Dr. Hankin had been led to the conclusion that the generally-accepted view that soaring flight depended on the use of ascending currents of air was untenable and that a new force produced by the action of sunlight must be invoked.

Dr. Hankin's views are criticised by Dr. G. T. Walker in a paper published recently* in the *Proceedings of the Cambridge Philosophical Society*. Dr. Walker describes his observations at Simla and in other parts of India. He discusses the variability of wind as shewn by a Dines anemometer and comes to the conclusion that the accelerations of the air are sufficient to provide the requisite forces on the wings of soaring birds. (The argument is open to criticism, however, in that the anemometer shews the variation of the wind at a fixed point not the variation of a point moving with the wind, and, moreover, the vertical movements which are complementary to the horizontal movements in eddies are ignored). The explanation of gliding in ascending air currents is more straightforward, but that does not diminish the charm of Dr. Walker's descriptions of the behaviour of the great birds. He writes: "I fully share Dr. Hankin's view . . . that birds derive a large amount of pleasure from gliding; I have several times at Simla seen the air suddenly filled with scavenger vultures and kites when the only obvious cause was a sudden change in the weather that made the air very turbulent and gave exceptional facilities for gliding."

It would be of interest to have Dr. Walker's explanation of Hankin's observations of the soaring flight of gulls following a steamer, recorded in the same number of the *Proceedings of the Cambridge Philosophical Society*. It appears that the region of "soarability" is not in the rising air immediately behind the boat but in the air further astern. Can it be that the birds prefer to float in the region where the air is travelling horizontally as it moves forward to feed the updraft close to the boat? The birds may be able to take advantage of the fact that this horizontal flow is not only faster near the water than higher up, but also faster than the motion of the boat.

However this may be, we note with interest that Dr. Hankin does not postulate a new force to explain the phenomenon.

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* *Vol. XXI. Part IV*, 1923.

## Forecasting of Night Minimum Temperatures from the Temperature and Humidity of the Preceding Afternoon

THE working rule that the lowest air-temperature of the night under a cloudless sky differs but little from the dew-point of the preceding afternoon is familiar. Various attempts to improve on it have been made from time to time. Amongst these may be mentioned that embodied in the formula given in the *U.S. Monthly Weather Review*, August, 1917, p. 407, as representing the experience of Mr. C. A. Donnel at Boise, Idaho, viz. :—

$$T = D - \tfrac{1}{5}(H - 45).$$

In this formula $T$ = expected minimum [Fahrenheit].
$D$ = dew-point at 20h.
$H$ = relative humidity at 20h.

To meet the conditions at the R.A.F. Station at Cranwell, where forecasts have to be made in the early afternoon in connection with the protection of aerodrome equipment, Captain W. H. Pick has modified Donnel's formula, and writes—

$$T = D - \tfrac{1}{4}(H - 63),$$

$H$ and $D$ referring to 15h. This new formula is found to give good results.

In connection with the same investigation Captain Pick has also examined the relation between the temperature recorded by a " grass minimum " thermometer at night and the dew-point of the previous afternoon.

His results are in close accordance with the formula—

$$G = \tfrac{1}{2}(D + 17)$$

where $G$ is the morning reading of the " grass minimum " thermometer, and $D$ is the dew-point the previous afternoon. This formula is appropriate for nights with little cloud and for values of $D$ from 32° F. to 50° F.

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## Solitary Gusts

MR. R. P. BATTY, who has made an examination of the records from the anemobiagraph at Larkhill, on Salisbury Plain, from January 1st, 1920, reports that only two isolated gusts have been registered during that period.

The first occurred at 11 h. 55 m. on December 22nd, 1921, and was similar to that at Balmakewan described in the February number of this magazine. The gust, which reached 59 miles per hour, rose from a mean wind of 23 miles per hour, the direction veering from SSW to SW by W. Temperature fell 2·5° F., while the barometer, which was previously falling slowly, rose rather less than 1 mb.

The other example, on March 8th, 1922, at 4 h. 55 m., was of a gust of 68 miles per hour, rising from a mean wind of 30 miles per hour. It was preceded, however, by an increased wind

speed for about 20 minutes. The wind veered from S to SW by S, and the temperature fell about 2° F. Previous to the gust, pressure was falling at the rate of 5 to 6 mb. per hour, but at the time of the gust it rose slightly before continuing its rapid fall. It should be noted that the barograph is situated about a mile from the anemometer.

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## Rain from a Clear Sky

AN interesting example of the rare phenomenon, rain from a clear sky, was observed by Mr. H. L. Pace, of the Meteorological Office, Cranwell, at Carlton Scroop, near Grantham, at about 20h. on Wednesday, March 21st, 1923. The shower was very slight and lasted only for a minute, but the drops were so large as to be distinctly audible falling on the ground. The sky was quite clear above, the only cloud visible being some strato-cumulus on the horizon. There was no fog, the visibility being fair, and there was hardly any surface wind.

Mr. Pace saw the rain upon coming out of his house and is unable to say whether there had been any cloud shortly before his observation was made. Enquiries have failed to elicit any answer concerning previous cloud from other observers, although there were several such.

There is some doubt as to whether rain can be produced without the previous existence of clouds. Hellmann* believes that many if not all apparent cases are falls from clouds that have passed out of sight. Some books, *e.g.*, Marriott's *Hints*, and the *Meteorological Glossary* state that the term "serein" is to be used for rain without clouds†. Hellmann makes it clear, however, that this is to perpetuate the misapprehension amongst French meteorologists of the older school as to the nature of dew. Serein (derived from the Latin "serum"—late in the day) was the old name for evening dew in contrast to rosée, morning dew.

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**Classification of the Hydrometeors*; trans. in *U.S. Monthly Weather Review*, July 1916 and Jan. 1917.

†The *New English Dictionary* quotes from Tyndall's *Heat*, 1870, §. 495. Reference to the original shows that in opposition to authors quoted by Melloni as attributing the "fine rain which sometimes falls in a clear sky after sunset" to radiation of the air, Tyndall attributes it to radiation from "the body itself, whose condensation produces the serein" *i.e.*, presumably from water-vapour on incipient drops.

## Radiation from the Sky

RADIATION MEASURED AT BENSON, OXON, 1923.

*Unit: one gramme calorie per square centimetre per day.*

ATMOSPHERIC RADIATION only (dark heat rays).

Averages for Readings about time of Sunset.

| | | Jan. | Feb. | Mar. |
|---|---|---|---|---|
| Cloudless days: | | | | |
| Number of readings ... ... | $n$ | 14 | 6 | 5 |
| Radiation from sky in zenith ... | $\pi I$ | 429 | 429 | 448 |
| Total radiation from sky ... | J | 461 | 433 | 481 |
| Total radiation from horizontal black surface on earth ... | X | 639 | 680 | 684 |
| Net radiation from earth ... | X—J | 178 | 192 | 203 |

DIFFUSE SOLAR RADIATION (luminous rays).

Averages for Readings between 9 h. and 15 h. G.M.T.

| | | | | |
|---|---|---|---|---|
| Cloudless days:— | | | | |
| Number of readings ... ... | $n_0$ | 8 | 5 | 2 |
| Radiation from sky in zenith ... | $\pi I_0$ | 17 | 22 | 29 |
| Total radiation from sky ... | $J_0$ | 26 | 34 | 40 |
| Cloudy days:— | | | | |
| Number of readings ... ... | $n_1$ | 6 | 6 | 7 |
| Radiation from sky in zenith ... | $\pi I_1$ | 41 | 54 | 89 |
| Total radiation from sky ... | $J_1$ | 35 | 50 | 72 |

Unit for I = gramme calorie per day per steradian per square centimetre
Unit for J and X = gramme calorie per day per square centimetre.
For description of instrument and methods of observation, see *The Meteorological Magazine*, October, 1920, and May, 1921.

## Underground Water Levels for 1922 in the North and South Downs

ATTENTION was drawn in *The Meteorological Magazine* for September, 1922, to the low underground water level then prevailing in the neighbourhood of the North Downs, north of Maidstone. Further investigation by Mr. Spencer Russell shows that the water was maintained at an extremely low level throughout the year. Naylor's Well, Detling, was dry from August to December, and the well at the Croft, Detling, also failed in December. The average depth in these two wells during 1922 was respectively 0·3 ft. and 0·6 ft., the average of the previous 10 years being 11·3 ft. and 17·7 ft. Other wells under observation in the North Downs were still falling in January, 1923. In

the South Downs, the wells at Chilgrove and Compton were, however, rising steadily at the end of the year, the rise being maintained during January, 1923.

There is little difference between the rainfalls for October to December of the North and South Downs, the totals at Detling and Chilgrove being 7·16 in. and 7·93 in. The difference in underground water level is probably due to the freer percolation in the Upper Chalk Zone of the South Downs as compared with that in the Middle Chalk of the North Downs.

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## The International Air Congress, London, 1923

THE meetings of the International Air Congress will take place on June 25th to June 30th at the Institution of Civil Engineers, Great George Street, S.W. 1. A programme of the Congress, containing a form of application for membership is now issued and is to be obtained from *The General Secretary, International Air Congress, London,* 1923, *7, Albemarle Street, W.*1. Papers of interest to meteorologists will be read in Group C, Air Transport and Navigation, which is to discuss such subjects as meteorology and communication, warnings, thunderstorms, instruments and wireless organization for meterological information, and flying in fog.

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## Review

BRITISH (TERRA NOVA) ANTARTIC EXPEDITION, 1910—1913. *Observations on the Aurora.* By C. S. WRIGHT, 4°, 12 × 9, pp. viii. + 46, *illus.*

*Determinations of Gravity.* By C. S. WRIGHT. 4°, 12 × 9, pp. 106, *illus.*

Harrison and Sons *for* The Committee of the Captain Scott Antarctic Fund, 1921. *Each* 7s. 6d. *net.*

Mr. C. S. Wright, who co-operated with Dr. Simpson in the meteorological and magnetic observations of Captain Scott's last expedition, has prepared a valuable report on the auroral observations made at Cape Evans, the winter quarters of the expedition, and at Cape Adare.

Cape Evans is comparatively close to the South Magnetic Pole and well inside the belt of greatest frequency of auroræ. Cape Adare is more favourably placed and the phenomenon was more brilliant there as well as more frequent. The daily variation in the position of the aurora is similar at the two stations. The typical sequence is for the aurora to appear as a glow to the ENE and to climb gradually. The arch reaches the zenith soon after midnight and passes over to the NW or SW sectors

a little later. Whilst the greatest frequency of auroræ is in the early morning hours the brightest examples and especially those associated with magnetic storms are best seen in the evening. The paper includes a brief discussion of the bearing of the observations on theories of the aurora.

A second paper by the same author is devoted to the determinations of gravity at Cape Evans and at Wellington, Melbourne and Christchurch.

Two matters are of interest to meteorologists. Difficulties were met with in the manipulation of the pendulum apparatus in the ice cave which was utilised the first year. The temperature of the cave varied from $-22°$ F. to $-4°$ F. (243*a* to 253*a*), and the presence of the observer was bound to produce much disturbance of the thermal equilibrium. Hoar-frost in the instrument case seems to have been eliminated after drying the air with calcium chloride for two weeks. In the second year the observations were made in the dark room of the living hut.

The final result of the observations at Cape Evans is that the local value of $g$ was 983·003 cm./sec.$^2$ The value assumed in meteorological tables for the latitude in question, 77°38′S, is 980·617 × 1·00236 or 982·93 cm./sec.$^2$ *i.e.*, the actual value is the higher by ·01 per cent. and pressures recorded by the mercury barometer and reduced by the ordinary tables must be increased by 0·1 mb. It is hardly necessary to point out that in view of the inevitable uncertainties of barometric observations such a correction is of no importance.

## News in Brief

The second triennial meeting of the Pan-Pacific Science Congress is to be held this year in Australia from August 13th to September 3rd. The provisional programme of subjects to be discussed includes "weather cycles and weather forecasting," "tropical diseases and geodesy," and "hygiene and climatology."

It is announced that Scott's ship, the *Discovery*, has been purchased by the Crown Agents for the Colonies on behalf of the government of the Falkland Isles. It will be employed chiefly in research on whaling, but opportunity will also be afforded for scientific work in other directions, particularly in oceanography, meteorology and magnetism.

Two important books have recently been published by the Cambridge University Press, the *Collected Scientific Papers of John Aitken, LL.D., F.R.S.*, edited by the late Dr. C. G. Knott; and *The Air and its Ways*, by Sir Napier Shaw, Sc.D., F.R.S.,

which takes its title from the Rede Lecture of 1921 and includes, also, other contributions to meteorology for schools and colleges.

It is announced by Royal Decree that as from March 1st, 1923, the Gregorian Calendar will be in use in Greece instead of the Julian. The National Observatory at Athens has been using the Gregorian Calendar for published weather statistics.

Captain C. J. P. Cave, of Stoner Hill, Petersfield, who is collecting reports of winter thunderstorms*, would be glad to receive any accounts of the storm which occurred on the night of Monday, March 26th. He particularly wishes information from Sussex and Surrey.

On March 7th, 1923, Mr. M. de Carle S. Salter delivered a lecture on *Rain* at the North London Collegiate School.

*Meteorological Office—Staff News.* On Tuesday, March 27th a team representing the Meteorological Office defeated a team representing the Directorate of Research in the second round of the "Air Ministry Inter-departmental Football Cup."

## The Weather of March, 1923

MARCH may be roughly divided into three periods, a mild, unsettled week, two weeks of easterly winds and rather cold weather, and a warm week with southerly breezes.

From the 1st to the 7th south-westerly winds were predominant and the weather generally unsettled, although rain was seldom heavy and some days had a fair amount of sunshine.

On the 7th a depression crossed England and an anticyclone developed in its rear, near the Faröes. This "high" moved eastwards and joined the anticyclone over northern Europe. A somewhat cold, "easterly" type of weather prevailed on the whole until the 20th, although on the 13th a trough of low pressure passed rapidly down the Channel, accompanied by heavy rains in London and the south. Towards the end of the month the continental "high" spread further southward, and light, warm, southerly winds and comparatively clear skies were experienced. Unusually high day temperatures were registered about the 27th. At Kew Observatory, Richmond, a maximum of 68° F. occurred on that date. Such a temperature has only once before been recorded there in March during the past 50 years Thunderstorms occurred locally in various parts of England between the 26th and the 29th.

The rainfall of the month was above the average in parts of the south of the British Isles but less than half the average fall in the northern half of Scotland.

*See *The Meteorological Magazine* for January, 1922.

The general rainfall in the British Isles, expressed as a percentage of the average was: England and Wales, 82; Scotland, 49; Ireland, 85; British Isles, 73.

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Early in the month stormy weather with much rain and violent thunderstorms occurred in France, and heavy floods were reported on the Seine, parts of Paris being flooded, and on many other rivers from the 1st to about the 8th. There was some loss of life. The drought still continued in Perpignan, where prayers for rain were ordered on the 16th. On the 8th there was an unusual fall of rain at Luxor in Egypt. Very severe floods in Macedonia, southern Serbia and Thessaly from the 15th to 18th were due to heavy rains and to warm winds melting the snow. The River Vardar was especially affected, and there was great loss of life and damage to property.

On the 23rd the Tigris was reported as rising to an unprecedented height in consequence of heavy rains and the melting of snow in Kurdistan; a day or two later it burst its banks, flooding three hundred square miles of desert and isolating Baghdad.

In North America the month was stormy. A disturbance which developed over the southern Rocky Mountains on the 5th moved eastward deepening rapidly, and caused gales on the coast on the 6th and 7th, with a blizzard in New York. Another storm of exceptional severity moved up the Mississippi valley on the 12th doing widespread damage, with a death-roll of 46. A storm swept the lower Mississippi valley on the 16th, causing 16 deaths, and again on the 19th a severe storm moving north-east caused blizzards and heavy snowfall in the western and central States, Chicago being isolated.

In Buenos Aires the unusually high March temperature of 94° F. recorded on the 12th, was followed by a fall of 36° F. in twelve hours. Pressure rose 5 mb. almost instantaneously. Near the South Orkneys there appears to be much ice.

Heavy rains in Nyasaland in the middle of March did great damage to the tobacco crop, and caused destructive floods on the Zambesi on the 19th and 20th, which interrupted railway communications. On the 26th the floods were subsiding. In Queensland (Australia) the month was one of drought.

The special message from Brazil states that in the north the rainfall averaged 53 mm. below normal. In the centre the distribution was irregular; in the south the fall averaged 100 mm. above normal, the excess being greatest in the extreme south. Prospects of the coffee crop are good; cotton is fair but is suffering from a deficiency of rain. There is still an absence of intense anticyclones and the general circulation presents no unusual features. At Rio de Janeiro pressure was 0·5 mb. and temperature 2·9° above normal.

# Rainfall Table for March, 1923

| CO. | STATION. | In. | mm. | Per-cent. of Av. | CO. | STATION. | In. | mm. | Per-cent. of Av. |
|---|---|---|---|---|---|---|---|---|---|
| *Lond.* | Camden Square..... | 2·39 | 61 | 131 | *Leics* | Leicester Town Hall... | 1·40 | 36 | ... |
| *Sur* . | Reigate, Hartswood... | 1·97 | 50 | ... | ,, . | Belvoir Castle..... | 1·19 | 30 | 66 |
| *Kent.* | Tenterden, View Tower | 2·16 | 55 | 101 | *Rut* . | Ridlington..... | 1·63 | 41 | ... |
| ,, . | Folkestone, Boro. San. | ... | ... | ... | *Linc.* | Boston, Skirbeck ..... | 1·71 | 43 | 110 |
| ,, . | Broadstairs ..... | ... | ... | ... | ,, . | Lincoln, Sessions House | 1·49 | 38 | 96 |
| ,, . | Sevenoaks, Speldhurst. | 2·52 | 64 | ... | ,, . | Skegness, Estate Office. | 2·05 | 52 | 124 |
| *Sus* . | Patching Farm..... | 2·66 | 68 | 124 | ,, . | Louth, Westgate ..... | 1·79 | 45 | 84 |
| ,, . | Eastbourne, Wilm. Sq. | 2·45 | 62 | 108 | ,, . | Brigg ..... | 1·60 | 41 | 88 |
| ,, . | Tottingworth Park.... | 2·43 | 62 | ... | *Notts.* | Worksop, Hodsock.... | 1·77 | 45 | 105 |
| *Hants* | Totland Bay, Aston... | 1·73 | 44 | 83 | *Derby* | Mickleover, Clyde Ho.. | 1·45 | 37 | 81 |
| ,, . | Fordingbridge, Oaklnds | 2·08 | 53 | 89 | ,, . | Buxton, Devon. Hos... | 2·29 | 58 | 55 |
| ,, . | Portsmouth, Vic. Park. | 1·67 | 43 | 84 | *Ches.* | Runcorn, Weston Pt... | 1·50 | 38 | 74 |
| ,, . | Ovington Rectory .... | 2·34 | 59 | 90 | ,, .. | Nantwich, Dorfold Hall | 1·53 | 39 | ... |
| ,, . | Grayshott ..... | 2·61 | 66 | 102 | *Lancs* | Bolton, Queen's Park . | 2·06 | 52 | ... |
| *Berks* | Wellington College... | 2·94 | 75 | 149 | ,, .. | Stonyhurst College.... | 1·44 | 37 | 39 |
| ,, . | Newbury, Greenham.. | 2·50 | 63 | 110 | ,, .. | Southport, Hesketh... | 1·35 | 34 | 60 |
| *Herts.* | Bennington House.... | ... | ... | ... | ,, .. | Lancaster, Strathspey. | 1·19 | 30 | ... |
| *Bucks* | High Wycombe ..... | 2·89 | 73 | 148 | *Yorks* | Sedbergh, Akay ..... | 2·10 | 53 | 46 |
| *Oxf.*. | Oxford, Mag. College.. | 2·66 | 68 | 174 | ,, . | Wath-upon-Dearne ... | 1·59 | 40 | 91 |
| *Nor* . | Pitsford, Sedgebrook.. | 1·89 | 48 | 107 | ,, . | Bradford, Lister Pk... | 1·66 | 42 | 68 |
| ,, . | Eye, Northolm..... | 1·82 | 46 | ... | ,, . | Oughtershaw Hall .... | 3·20 | 81 | ... |
| *Beds.* | Woburn, Crawley Mill. | ... | ... | ... | ,, . | Wetherby, Ribston H.. | 2·09 | 53 | 107 |
| *Cam.* | Cambridge, Bot. Gdns. | 1·69 | 43 | 115 | *ERY* | Hull, Pearson Park ... | 1·53 | 39 | 84 |
| *Essex* | Chelmsford, CountyLab | ... | ... | ... | ,, . | Holme-on-Spalding ... | 1·67 | 42 | ... |
| ,, . | Lexden, Hill House... | 1·37 | 35 | ... | ,, . | Lowthorpe, The Elms. | 1·32 | 33 | 66 |
| *Suff* . | Hawkedon Rectory ... | 1·39 | 35 | 73 | *NRY* | West Witton, Ivy Ho.. | 1·48 | 38 | ... |
| ,, . | Haughley House..... | 1·10 | 28 | ... | ,, . | Pickering, Hungate ... | 1·67 | 42 | ... |
| *Norf.* | Beccles, Geldeston.... | 1·38 | 35 | 80 | ,, . | Middlesbrough ..... | 1·28 | 33 | 82 |
| ,, . | Norwich, Eaton ..... | 1·58 | 40 | 83 | ,, . | Baldersdale, Hury Res. | 1·91 | 49 | 63 |
| ,, . | Blakeney ..... | 1·50 | 38 | 91 | *Durh.* | Ushaw College ..... | 1·76 | 45 | 80 |
| ,, . | Swaffham ..... | 1·46 | 37 | 82 | *Nor* . | Newcastle, Town Moor. | 1·89 | 48 | 90 |
| *Wilts.* | Devizes, Highclere.... | 2·13 | 54 | ... | ,, . | Bellingham Manor.... | 1·46 | 37 | ... |
| *Dor* . | Evershot, Melbury Ho. | 1·59 | 40 | 53 | ,, . | Lilburn Tower Gdns... | 1·85 | 47 | 77 |
| ,, . | Weymouth, Westham. | 1·28 | 33 | 77 | *Cumb* | Penrith, Newton Rigg.. | ... | ... | ... |
| ,, . | Shaftesbury, Abbey Ho. | 2·00 | 51 | 85 | ,, . | Carlisle, Scaleby Hall . | ·80 | 20 | 33 |
| *Devon* | Plymouth, The Hoe... | 2·13 | 54 | 74 | ,, . | Seathwaite ..... | 5·10 | 129 | 46 |
| ,, . | Polapit Tamar ..... | 1·89 | 48 | 63 | *Glam.* | Cardiff, Ely P. Stn..... | 2·10 | 43 | 65 |
| ,, . | Ashburton, Druid Ho.. | 2·39 | 61 | 54 | ,, . | Treherbert, Tynywaun | 3·50 | 89 | ... |
| ,, . | Cullompton ..... | 1·50 | 38 | 55 | *Carm* | Carmarthen Friary.... | 2·29 | 58 | 60 |
| ,, . | Sidmouth, Sidmount .. | 1·44 | 37 | 59 | ,, . | Llanwrda, Dolaucothy. | 3·01 | 77 | 65 |
| ,, . | Filleigh, Castle Hill ... | 1·78 | 45 | ... | *Pemb* | Haverfordwest, Portf'd | ... | ... | ... |
| ,, . | Hartland Abbey..... | 1·25 | 32 | ... | *Card.* | Gogerddan..... | ... | ... | ... |
| *Corn.* | Redruth, Trewirgie ... | 2·78 | 70 | 77 | ,, . | Cardigan, County Sch. . | 1·75 | 44 | ... |
| ,, . | Penzance, Morrab Gdn. | 2·22 | 56 | 69 | *Brec* . | Crickhowell, Talymaes | 3·00 | 76 | ... |
| ,, . | St. Austell, Trevarna.. | 2·60 | 66 | 76 | *Rad* . | Birm. W. W. Tyrmynydd | 3·31 | 84 | 62 |
| *Som* | Street, Hind Hayes ... | 1·54 | 39 | ... | *Mont.* | Lake Vyrnwy ..... | 2·81 | 71 | 66 |
| *Glos.*, | Clifton College ..... | 1·53 | 39 | 61 | *Denb.* | Llangynhafal ..... | ·99 | 25 | ... |
| ,, . | Cirencester ..... | 2·36 | 60 | 100 | *Mer* . | Dolgelly, Bryntirion.. | 2·25 | 57 | 46 |
| *Here.* | Ross, County Obsy. ... | ... | ... | ... | *Carn.* | Llandudno ..... | ·76 | 19 | 35 |
| ,, . | Ledbury, Underdown. | 1·31 | 33 | 69 | ,, . | Snowdon, L. Llydaw 9 | 5·00 | 127 | ... |
| *Salop* | Church Stretton..... | 1·75 | 44 | 74 | *Ang* . | Holyhead, Salt Island. | 1·12 | 28 | 43 |
| ,, . | Shifnal, Hatton Grange | 1·57 | 40 | 85 | ,, . | Lligwy ..... | 1·23 | 31 | ... |
| *Staff.* | Tean, The Heath Ho... | 2·26 | 57 | 96 | *Man.* | Douglas, Boro' Cem... | 1·69 | 43 | 57 |
| *Worc.* | Ombersley, Holt Lock. | 1·39 | 35 | 82 | *Guer.* | St. Peter Port, Grange. | 2·39 | 61 | 97 |
| ,, . | Blockley, Upton Wold. | 2·25 | 57 | 105 | *Wigt.* | Stoneykirk, Ardwell Ho | 1·45 | 37 | 56 |
| *War* | Farnborough..... | 1·95 | 49 | 92 | ,, . | Pt. William, Monreith . | 1·49 | 38 | ... |
| ,, . | Birminghm, Edgbaston | ... | ... | ... | *Kirk.* | Carsphairn, Shiel. .... | 4·21 | 107 | ... |

## Rainfall Table for March, 1923——*continued*

| CO. | STATION. | In. | mm. | Per-cent. of Av. | CO. | STATION. | In. | mm | Per-cent. of Av. |
|---|---|---|---|---|---|---|---|---|---|
| *Kirk.* | Dumfries, Cargen..... | 1·96 | 50 | 54 | *Caith* | Loch More, Achfary... | 1·09 | 28 | 17 |
| *Dum* | Drumlanrig ..... | 2·31 | 59 | 62 | ,, .. | Wick ..... | ·72 | 18 | 32 |
| *Roxb* | Branxholme ..... | 1·19 | 30 | 41 | *Ork* . | Pomona, Deerness .... | ·52 | 13 | 19 |
| *Selk* . | Ettrick Manse..... | 2·98 | 76 | ... | *Shet* . | Lerwick ..... | ·94 | 24 | 30 |
| *Berk.* | Marchmont House .... | 1·03 | 26 | 39 | *Cork.* | Caheragh Rectory .... | 4·92 | 125 | ... |
| *Hadd* | North Berwick Res.... | ·57 | 15 | 30 | ,, .. | Dunmanway Rectory. | 4·31 | 109 | 88 |
| *Midl* | Edinburgh, Roy. Obs.. | ·78 | 20 | 44 | ,, .. | Ballinacurra ..... | 3·61 | 92 | 127 |
| *Lan* . | Biggar ..... | 1·14 | 29 | 46 | ,, .. | Glanmire, Lota Lo. ... | 4·06 | 103 | 131 |
| *Ayr* . | Kilmarnock, Agric. C.. | 1·94 | 49 | 67 | *Kerry* | Valencia Obsy. ..... | ... | ... | ... |
| ,, . | Girvan, Pinmore..... | 2·41 | 61 | 64 | ,, . | Gearahameen ..... | 6·30 | 160 | ... |
| *Renf.* | Glasgow, Queen's Pk.. | 1·63 | 41 | 62 | ,, . | Killarney Asylum..... | ... | ... | ... |
| ,, . | Greenock, Prospect H.. | 3·31 | 84 | 69 | ,, . | Darrynane Abbey .... | 4·13 | 105 | 101 |
| *Bute.* | Rothesay, Ardencr'g.. | 2·90 | 74 | 81 | *Wat* . | Waterford, Brook Lo.. | ... | ... | ... |
| ,, . | Dougarie Lodge ..... | 2·32 | 59 | ... | *Tip* . | Nenagh, Cas. Lough... | 2·87 | 73 | 93 |
| *Arg* . | Glen Etive..... | ... | ... | ... | ,, . | Tipperary ..... | 2·61 | 66 | ... |
| ,, . | Oban ..... | 2·24 | 57 | ... | ,, . | Cashel, Ballinamona .. | ... | ... | ... |
| ,, . | Poltalloch ..... | 3·10 | 79 | 81 | *Lim* . | Foynes, Coolnanes .... | 3·15 | 80 | 107 |
| ,, . | Inveraray Castle..... | 2·92 | 74 | 46 | ,, . | Castleconnell Rec. .... | 3·17 | 81 | ... |
| ,, . | Islay, Eallabus..... | 3·13 | 80 | 82 | *Clare* | Inagh, Mount Callan .. | 4·49 | 114 | ... |
| ,, . | Mull, Benmore ..... | 2·40 | 61 | ... | ,, . | Broadford, Hurdlest'n. | 3·38 | 86 | ... |
| ,, . | Mull, Quinish ..... | 1·95 | 49 | 44 | *Wexf* | Gorey, Courtown Ho... | 2·86 | 73 | 124 |
| *Kinr.* | Loch Leven Sluice .... | 1·69 | 43 | 57 | *Kilk.* | Kilkenny Castle ..... | 2·22 | 56 | 97 |
| *Perth* | Loch Dhu ..... | 4·30 | 109 | 65 | *Wic* . | Rathnew, Clonmannon | 2·48 | 63 | ... |
| ,, .. | Balquhidder, Stronvar. | 3·70 | 94 | 60 | *Cars.* | Hacketstown Rectory . | 2·55 | 65 | 91 |
| ,, .. | Crieff, Strathearn Hyd. | 2·31 | 59 | 72 | *QCo.* . | Blandsfort House..... | ... | ... | ... |
| ,, .. | Blair Atholl..... | 1·71 | 43 | 66 | ,, | Mountmellick ..... | 2·62 | 67 | ... |
| ,, . | Coupar Angus School.. | 1·49 | 38 | 68 | *KCo.* | Birr Castle..... | 2·36 | 60 | 98 |
| *Forf.* | Dundee, E. Necropolis. | 1·45 | 37 | 70 | *Dubl.* | Dublin, FitzWm. Sq... | 1·14 | 29 | 59 |
| ,, . | Pearsie House..... | ... | ... | ... | ,, . | Balbriggan, Ardgillan . | 1·33 | 34 | 66 |
| ,, . | Montrose, Sunnyside.. | 1·55 | 39 | 75 | *W.M* | Athlone, Twyford..... | ... | ... | ... |
| *Aber.* | Braemar Bank ..... | 1·27 | 32 | 43 | ,, . | Mullingar, Belvedere . | ... | ... | ... |
| ,, . | Logie Coldstone Sch. .. | 1·07 | 27 | 41 | *Long* | Castle Forbes Gdns.... | 1·87 | 47 | 63 |
| ,, . | Aberdeen, Cranford Ho | 1·74 | 46 | 67 | *Gal* . | Galway, Waterdale ... | 2·41 | 61 | ... |
| ,, . | Fyvie Castle ..... | ·87 | 22 | ... | ,, . | Ballynahinch Castle .. | ... | ... | ... |
| *Mor* | Gordon Castle..... | ·59 | 15 | 25 | ,, . | Woodlawn ..... | ... | ... | ... |
| ,, | Grantown-on-Spey.... | ·98 | 25 | 37 | *Mayo* | Crossmolina, Enniscoe | ... | ... | ... |
| *Na* . | Nairn, Delnies..... | ·58 | 15 | 31 | ,, . | Blacksod Point..... | ... | ... | ... |
| *Inv.* . | Ben Alder Lodge ..... | 3·08 | 78 | ... | ,, . | Westport House..... | 3·15 | 80 | 81 |
| ,, . | Kingussie, The Birches | ·55 | 14 | ... | ,, . | Delphi Lodge ..... | 6·03 | 153 | ... |
| ,, . | Fort Augustus ..... | ·90 | 23 | 25 | *Sligo* | Markree Obsy. ..... | 2·85 | 72 | 84 |
| ,, . | Loch Quoich, Loan.... | 5·20 | 132 | ... | *Ferm* | Enniskillen, Portora .. | 2·17 | 55 | ... |
| ,, . | Glenquoich ..... | 3·55 | 90 | 37 | *Arm.* | Armagh Obsy. ..... | 1·48 | 37 | 63 |
| ,, . | Inverness, Culduthel R. | ... | ... | ... | *Down* | Warrenpoint ..... | 3·09 | 79 | ... |
| ,, . | Arisaig, Faire-na-Squir | 2·03 | 52 | ... | ,, . | Seaforde ..... | 3·14 | 80 | 108 |
| ,, . | Fort William..... | 2·67 | 68 | 40 | ,, . | Donaghadee ..... | 1·32 | 33 | 60 |
| ,, . | Skye, Dunvegan..... | 2·72 | 69 | ... | ,, . | Banbridge, Milltown . | 1·23 | 31 | 56 |
| ,, . | Barra, Castlebay ..... | 1·27 | 32 | ... | *Antr.* | Belfast, Cavehill Rd. .. | 2·53 | 64 | ... |
| *R&C* | Alness, Ardross Cas. .. | 1·08 | 27 | 33 | ,, . | Glenarm Castle..... | 2·09 | 53 | ... |
| ,, . | Ullapool..... | ·81 | 21 | ... | ,, . | Ballymena, Harryville | 2·31 | 59 | 73 |
| ,, . | Torridon, Bendamph.. | 3·16 | 80 | 42 | *Lon* . | Londonderry, Creggan | 1·87 | 47 | 58 |
| ,, . | L. Carron, Plockton... | 1·66 | 42 | ... | *Tyr* . | Donaghmore ..... | 2·05 | 52 | ... |
| ,, . | Stornoway ..... | 1·27 | 32 | 31 | ,, . | Omagh, Edenfel ..... | 3·14 | 80 | 100 |
| *Suth.* | Dunrobin Castle..... | ... | ... | ... | *Don* . | Malin Head ..... | 1·36 | 35 | 59 |
| ,, . | Lairg ..... | ·60 | 15 | ... | ,, . | Letterkenny Hos ..... | 2·52 | 64 | 66 |
| ,, . | Forsinard ..... | ... | ... | ... | ,, . | Dunfanaghy ..... | ... | ... | ... |
| ,, . | Tongue Manse..... | ·93 | 24 | 28 | ,, . | Narin, Kiltoorish ..... | 2·96 | 75 | ... |
| ,, . | Melvich School..... | ·61 | 15 | 21 | ,, . | Killybegs, Rockmount. | 3·80 | 97 | 75 |

# Climatological Table for the British Empire, October, 1922

| STATIONS | PRESSURE | | TEMPERATURE | | | | | | | Relative Humidity | Mean Cloud Am'nt | PRECIPITATION | | | BRIGHT SUNSHINE | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Absolute | | Mean Values | | | | Mean | | | | | | | |
| | Mean of Day M.S.L. | Diff. from Normal | Max. | Min. | Max. | Min. | ½ max. and min. | Diff. from Normal | Wet Bulb. | | | Am'nt | Diff. from Normal | Days | Hours per day | Percentage of possible. |
| | mb. | mb. | °F. | °F. | °F. | °F. | °F. | °F. | °F. | % | 0—10 | mm. | mm. | | | |
| London, Kew Obsy. | 1017·7 | + 4·0 | 65 | 28 | 54·5 | 41·9 | 48·2 | − 1·7 | 45·6 | 76 | 5·7 | 19 | − 50 | 9 | 3·8 | 35 |
| Gibraltar | 1013·5 | − 1·7 | 82 | 52 | 72·9 | 60·6 | 66·7 | + 0·2 | 61·2 | 75 | 5·1 | 149 | + 65 | 13 | ... | ... |
| Malta | 1014·5 | − 1·2 | 85 | 61 | 75·4 | 67·1 | 71·3 | + 1·3 | 66·3 | 80 | 4·8 | 21 | − 47 | 3 | 6·2 | 55 |
| Sierra Leone | 1012·0 | 0·0 | 88 | 69 | 85·5 | 72·5 | 79·0 | − 1·2 | 74·6 | 78 | 7·5 | 309 | − 12 | 24 | ... | ... |
| Lagos, Nigeria | 1010·4 | − 1·3 | 87 | 71 | 84·9 | 73·7 | 79·3 | + 0·2 | 76·1 | 80 | 8·2 | 391 | +195 | 20 | ... | ... |
| Kaduna, Nigeria | 1011·8 | − 0·5 | 90 | ... | 84·8 | ... | ... | ... | 69·7 | 76 | ... | 104 | + 44 | 14 | ... | ... |
| Zomba, Nyasaland | 1010·1 | − 0·4 | 94 | 55 | 87·1 | 63·5 | 75·3 | + 1·2 | ... | 85 | 3·5 | 51 | + 13 | 7 | ... | ... |
| Salisbury, Rhodesia | 1010·0 | − 1·0 | 94 | 51 | 83·7 | 57·2 | 70·5 | − 0·3 | 60·5 | 53 | 3·4 | 47 | + 17 | 13 | ... | ... |
| Cape Town | 1018·3 | + 0·9 | 93 | 44 | 71·0 | 52·2 | 61·6 | + 0·6 | 57·8 | 64 | 5·0 | 38 | − 6 | 12 | ... | ... |
| Johannesburg | 1014·2 | + 0·2 | 84 | 36 | 72·8 | 50·8 | 61·8 | − 0·8 | 52·3 | 61 | 3·4 | 80 | + 19 | 12 | 8·6 | 68 |
| Mauritius | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Bloemfontein | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Calcutta, Alipore Obsy. | 1010·7 | + 1·3 | 92 | 65 | 86·2 | 72·8 | 79·5 | − 1·2 | 74·0 | 83 | 3·7 | 57 | − 42 | *5 | ... | ... |
| Bombay | 1010·3 | + 0·6 | 92 | 74 | 89·4 | 76·7 | 83·1 | + 0·8 | †75·3 | †80 | †2·8 | 15 | − 32 | *2 | ... | ... |
| Madras | 1009·8 | + 0·9 | 97 | 69 | 87·4 | 75·0 | 81·2 | − 0·9 | 75·8 | 80 | 7·2 | 449 | +163 | *11 | 4·3 | ... |
| Colombo, Ceylon | 1010·3 | + 0·5 | 88 | 70 | 86·4 | 74·0 | 80·2 | − 0·3 | 76·4 | 70 | 8·4 | 277 | − 80 | 21 | ... | ... |
| Hong Kong | 1014·2 | + 0·6 | 84 | 66 | 80·5 | 72·1 | 76·3 | − 0·6 | 69·8 | 74 | 5·6 | 51 | − 74 | 10 | 7·2 | 62 |
| Sandakan | ... | ... | 90 | 73 | 87·3 | 75·1 | 81·2 | − 0·3 | 76·9 | 80 | ... | 251 | − 3 | 15 | ... | ... |
| Sydney | 1013·7 | − 1·2 | 95 | 47 | 74·3 | 56·5 | 65·4 | + 1·9 | 59·1 | 56 | 3·6 | 82 | + 7 | 6 | 8·1 | 63 |
| Melbourne | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| Adelaide | 1015·8 | − 0·3 | 103 | 40 | 72·7 | 51·8 | 62·3 | + 0·4 | 53·6 | 51 | 4·4 | 43 | − 1 | 11 | 8·1 | 65 |
| Perth, W. Australia | 1017·3 | + 0·4 | 95 | 42 | 70·8 | 53·2 | 62·0 | + 1·1 | 57·0 | 62 | 4·6 | 30 | − 24 | 12 | 8·5 | 66 |
| Coolgardie | 1015·1 | − 0·1 | 98 | 37 | 79·7 | 50·3 | 65·0 | + 1·4 | 55·1 | 34 | 2·9 | 2 | − 17 | 3 | ... | ... |
| Brisbane | 1015·8 | − 0·3 | 87 | 54 | 80·3 | 61·6 | 70·9 | + 1·0 | 65·8 | 65 | 3·5 | 53 | − 14 | 7 | ... | ... |
| Hobart, Tasmania | 1007·6 | − 3·0 | 91 | 40 | 63·5 | 47·0 | 55·3 | + 1·3 | 49·1 | 62 | 6·7 | 79 | + 22 | 23 | 6·2 | 47 |
| Wellington, N.Z. | 1014·9 | + 2·6 | 71 | 37 | 64·0 | 50·1 | 57·1 | + 2·8 | 52·1 | 71 | 5·8 | 59 | − 48 | 13 | 7·1 | 54 |
| Suva, Fiji | 1013·6 | + 0·4 | 88 | 57 | 81·5 | 63·7 | 72·6 | − 3·4 | 72·9 | 78 | 6·7 | 213 | + 15 | 13 | ... | ... |
| Kingston, Jamaica | 1011·3 | − 0·6 | 92 | 69 | 88·5 | 72·3 | 80·4 | − 0·1 | ... | 74 | 4·9 | 105 | − 85 | 9 | ... | ... |
| Grenada, W.I. | 1011·4 | + 0·4 | 90 | 71 | 85·0 | 74·3 | 79·7 | − 0·4 | 75·0 | 78 | 3·8 | 140 | − 46 | 19 | ... | ... |
| Toronto | 1015·6 | − 2·4 | 83 | 25 | 58·5 | 41·1 | 49·8 | + 2·9 | 43·7 | 80 | 4·0 | 24 | − 38 | 8 | ... | ... |
| Winnipeg | 1014·5 | − 0·8 | 86 | 18 | 53·5 | 33·6 | 43·5 | + 2·7 | 38·2 | 86 | 5·5 | 13 | − 25 | 10 | ... | ... |
| St. John, N.B. | 1011·5 | − 5·0 | 72 | 25 | 52·1 | 38·9 | 45·5 | + 0·2 | 42·9 | 83 | 6·7 | 129 | + 14 | 13 | ... | ... |
| Victoria, B.C. | 1016·2 | − 1·4 | 67 | 39 | 56·9 | 46·5 | 51·7 | + 1·3 | 48·8 | 90 | 6·5 | 79 | + 14 | 15 | ... | ... |

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen. † Observations taken at 8 *h.* from October, 1922.